Applications of Satellite Soil Moisture in Drought Monitoring and Weather Forecast Improvements

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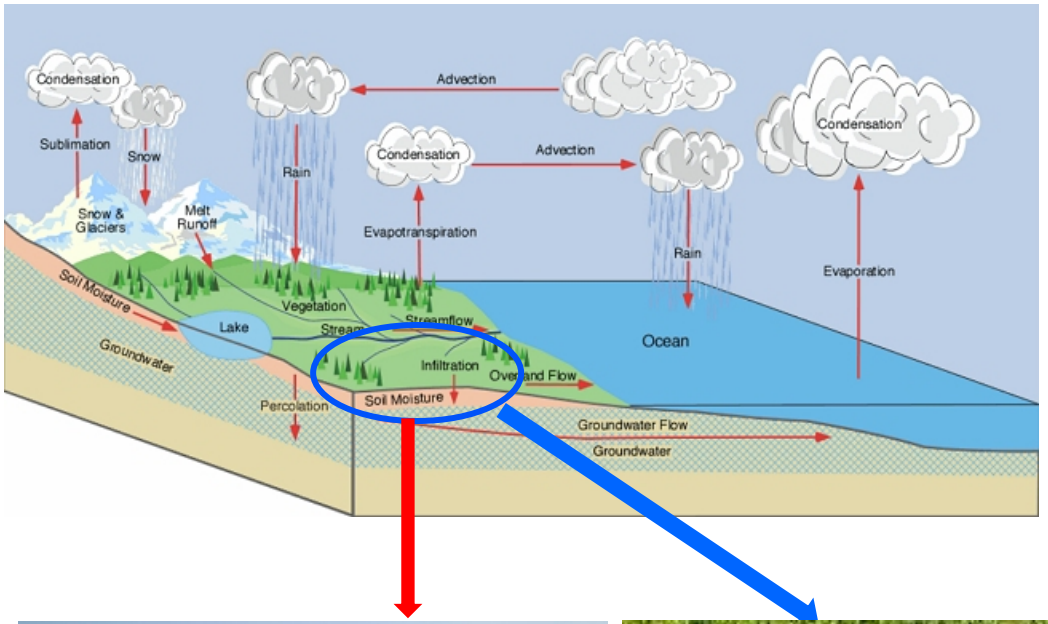
Outline

- ***Satellite Soil Moisture***
- ***Blended Drought Index***
- ***Improvements in Weather Forecasts***
- ***Summary***

1. Satellite Soil Moisture

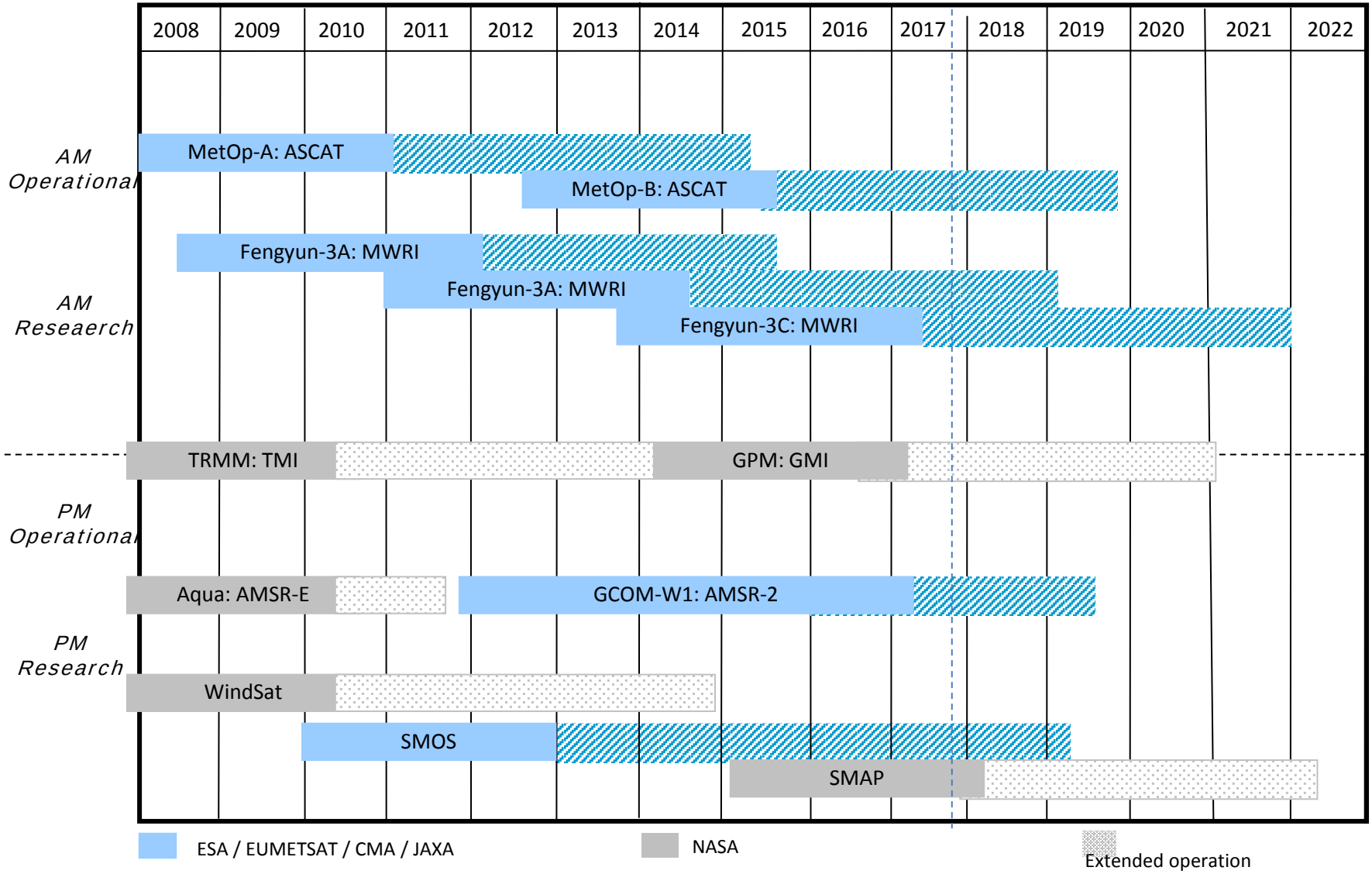


Soil moisture has long memory to ***impact the exchanges of energy, water and carbon*** *between the land surface and atmosphere (Zhan et al., 2012; Yin et al., 2015c, 2016)*

Soil moisture statuses at various soil layers ***are very important to well understand drought and flood development****.*

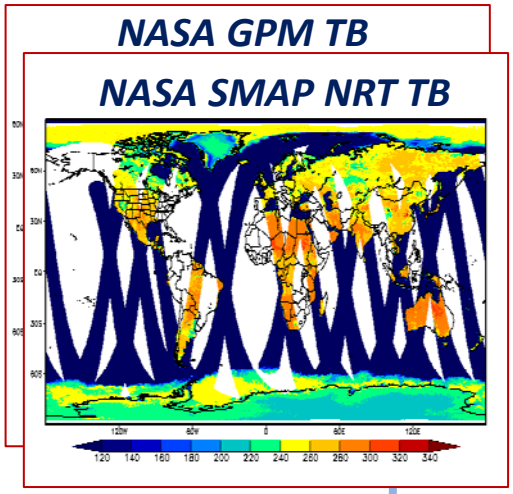
1. Satellite Soil Moisture

Current and Future Soil Moisture Satellites

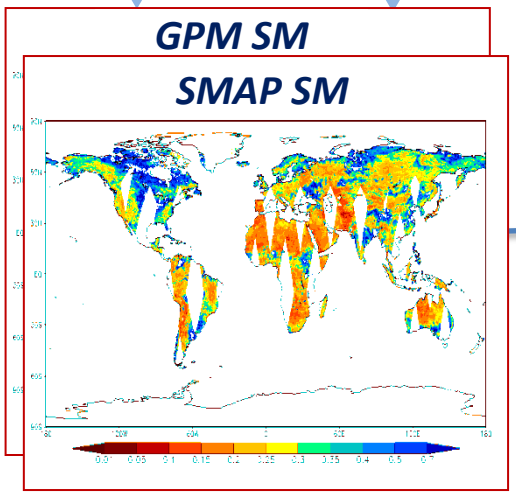


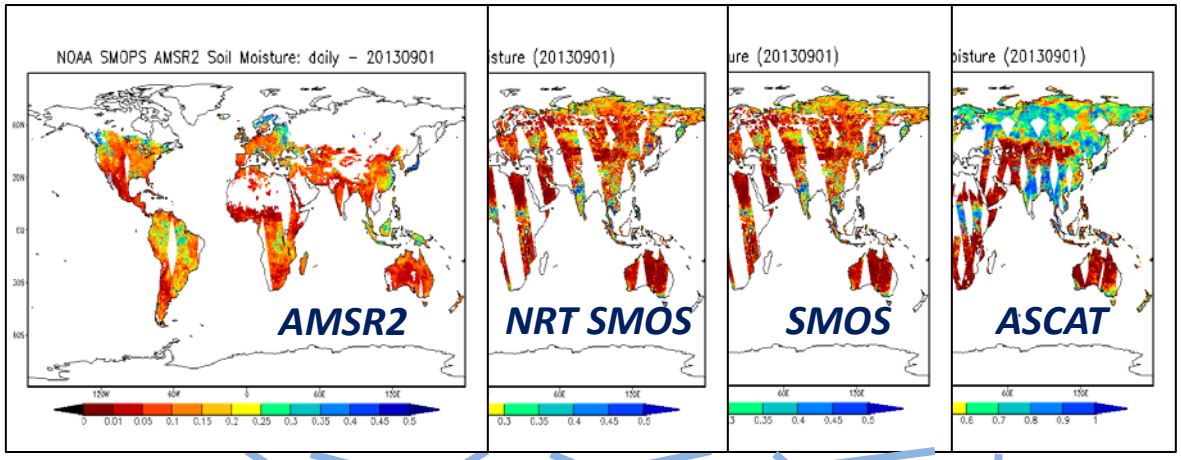
1. Satellite Soil Moisture

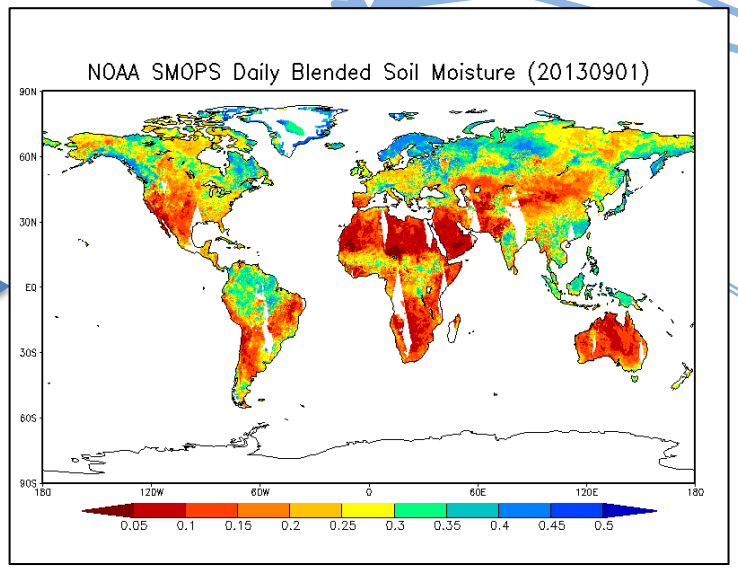
Soil Moisture Operational Product System (SMOPS)



NOAA Ancillary Data







NWP models
NCEP
GFS/NAM
NLDAS/GLDAS
AFWA, etc

2. Blended Drought Index

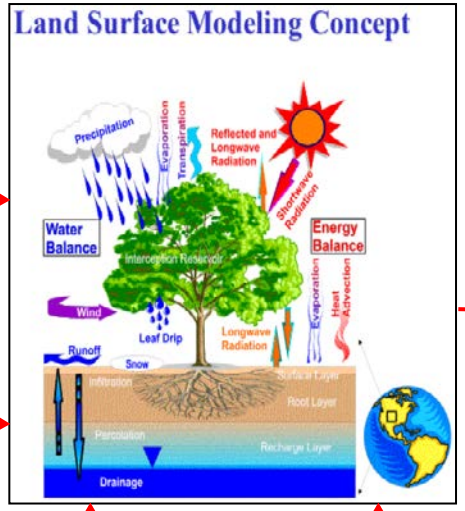
***Triple Collocation Error Model (TCEM)*--Three separate drought detection sources:**

Microwave remote sensing;
Noah model SM (NLSM);
Evaporative stress index (ESI).

Noah3.2 LSM implemented in LIS 6.2

GDAS: downward SW/LW radiation, near-surface t_{air} / RH/wind and surface P

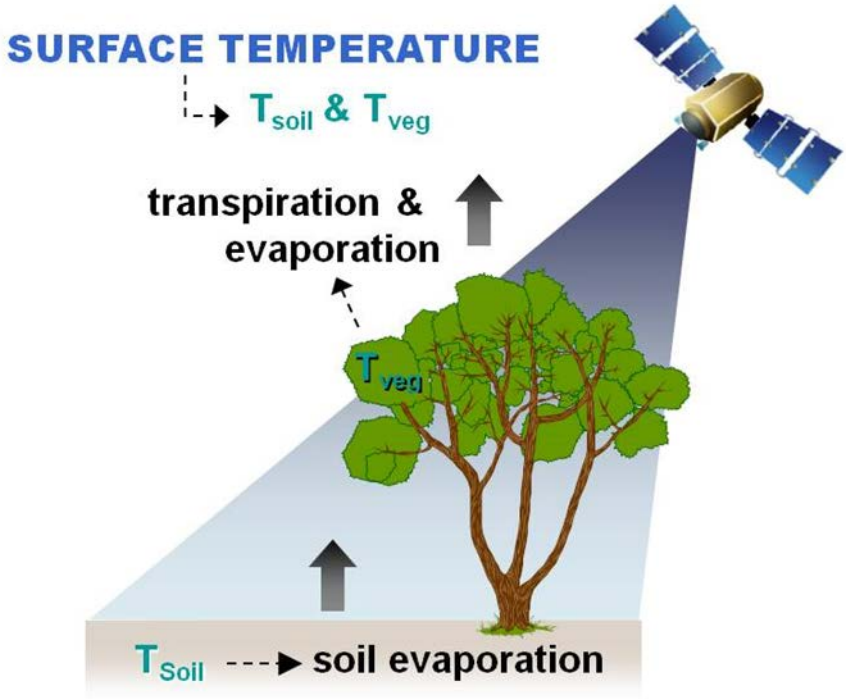
GLDAS: Precip



Daily Root-zone SM (NLSM)

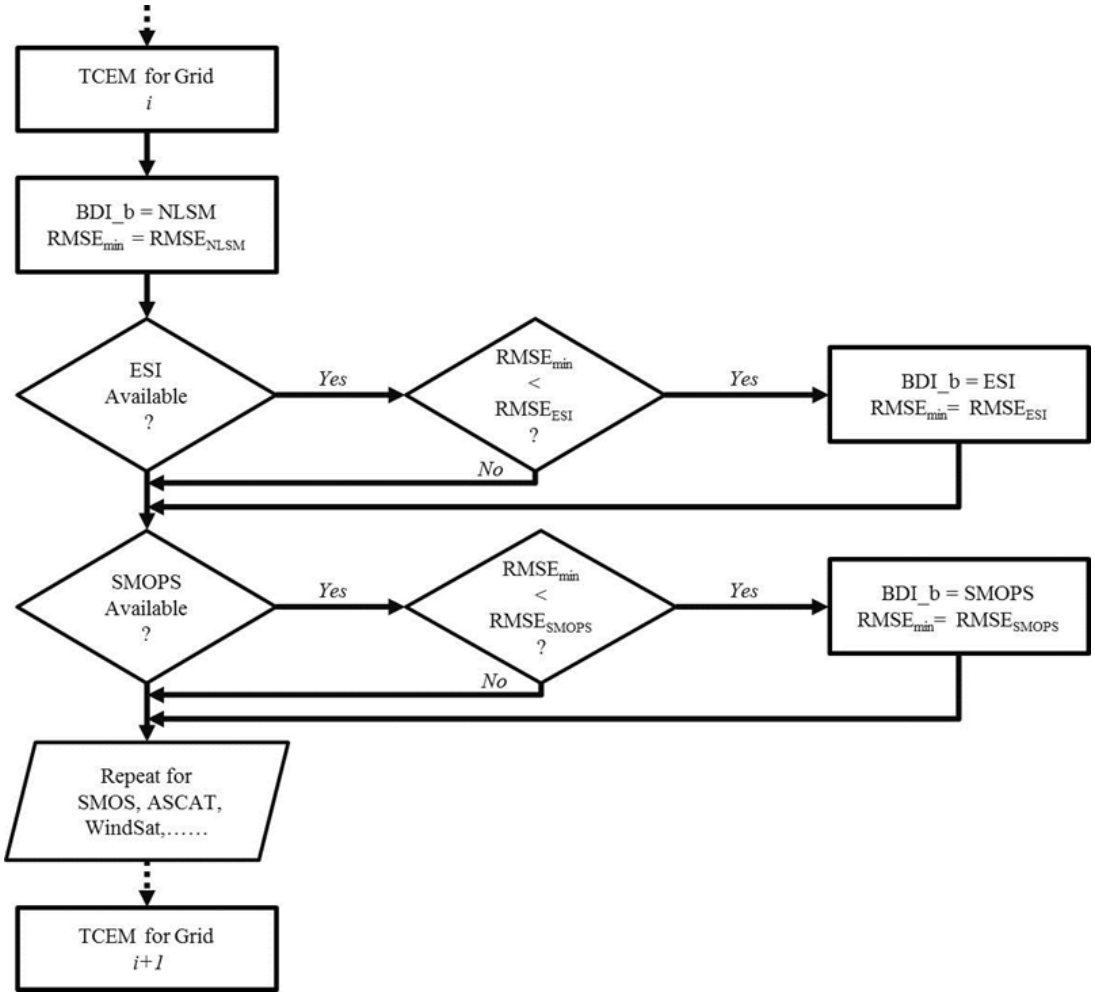
2007-10 MODIS C5 land cover map

8-day MODIS LAI-based GVF



ALEXI model-based ESI

2. Blended Drought Index

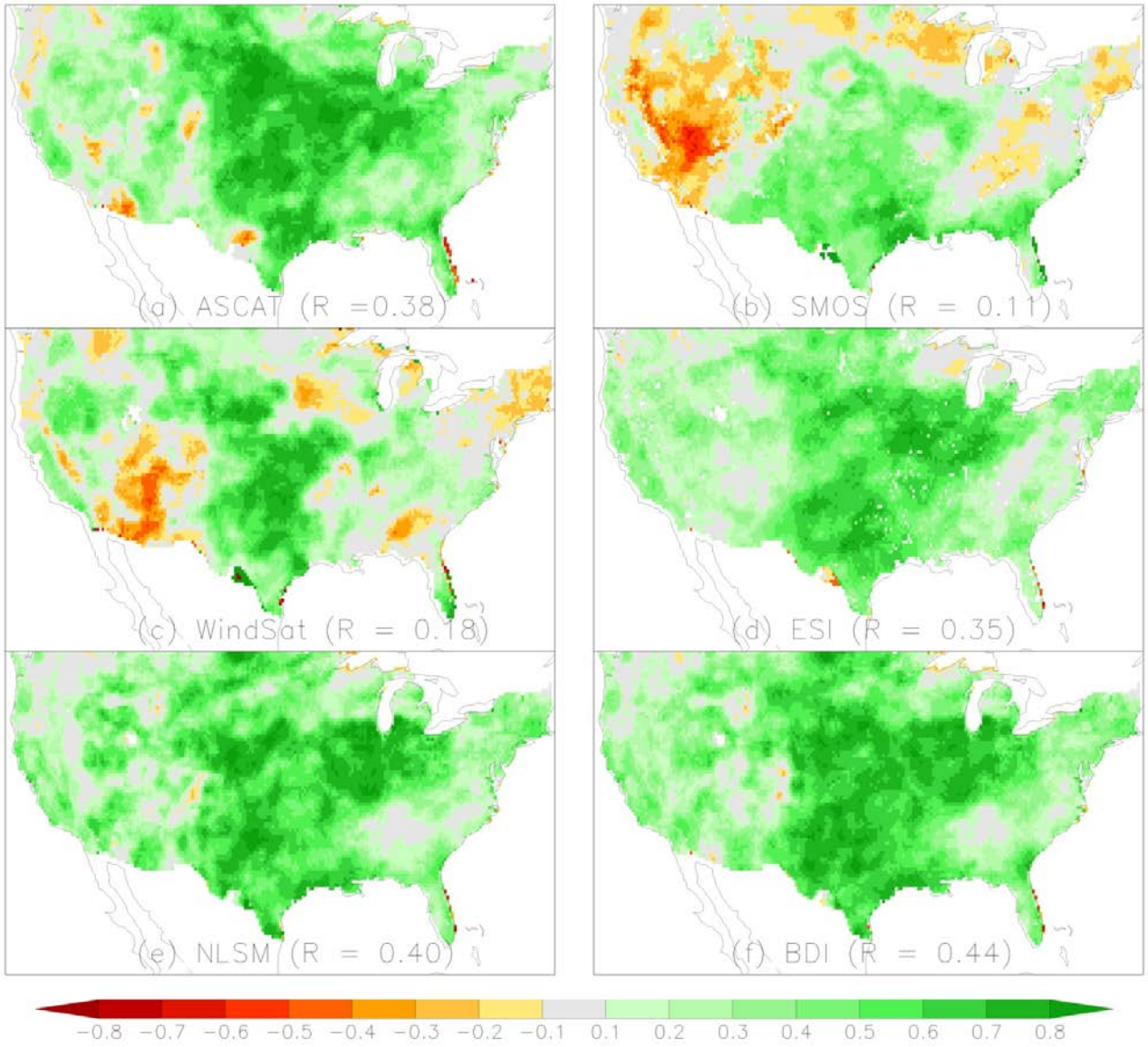


Schematic for the production of the Blended Drought Index.

BDI_b: each pixel will be filled by the retrievals that are proven to be more accurate than others, which can ensure all of the grids across global domain can be covered by the optimal drought estimation information.

2. Blended Drought Index

Validation with USDM



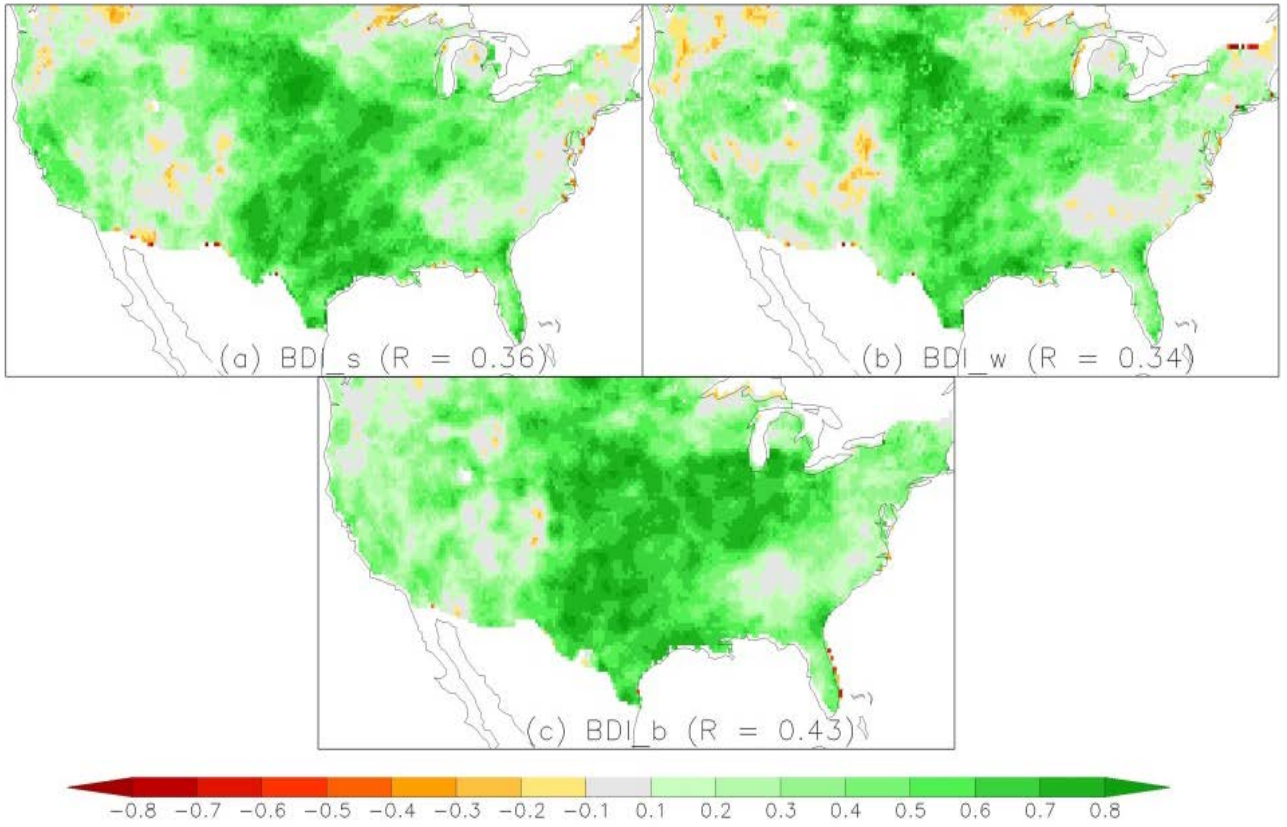
Correlation coefficients (R) *between USDM and (a) ASCAT, (b) SMOS, (c) WindSat, (d) ESI, (e) NLSM and (f) BDI_b*. The grey color indicates insignificantly.

2. Blended Drought Index

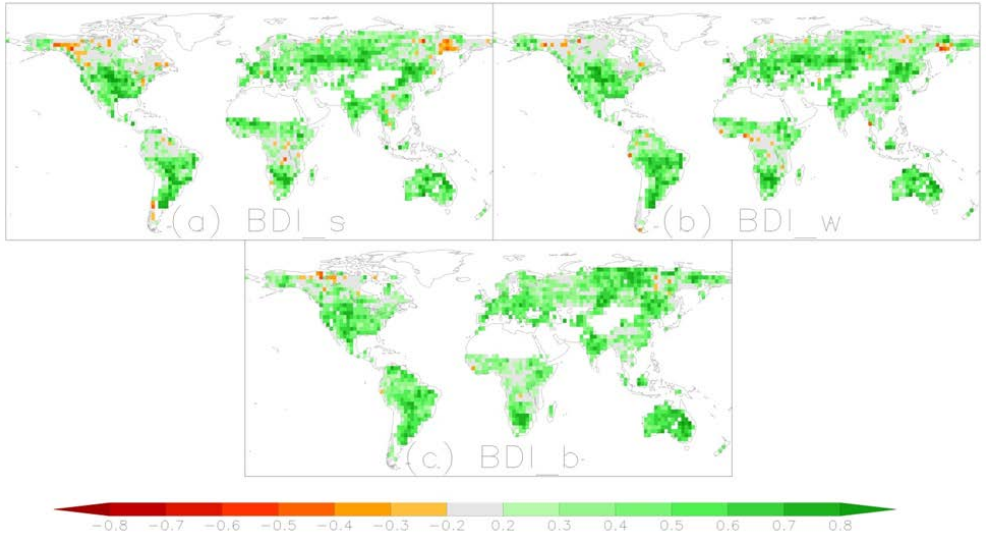
(1) the ***BDI_s*** subjectively samples all of the available retrievals using an equal weighted-average blending technique;

(2) the ***BDI_w*** uses weights based on error statistics assessed using the TCEM; and

(3) the ***BDI_b*** framework objectively integrates drought estimations which exhibit the lowest TCEM-based root mean square errors



2. Blended Drought Index



With respect to PDSI:

CONUS: BDI_s (0.45), ***BDI_w (0.47)***, ***BDI_b (0.47)***;

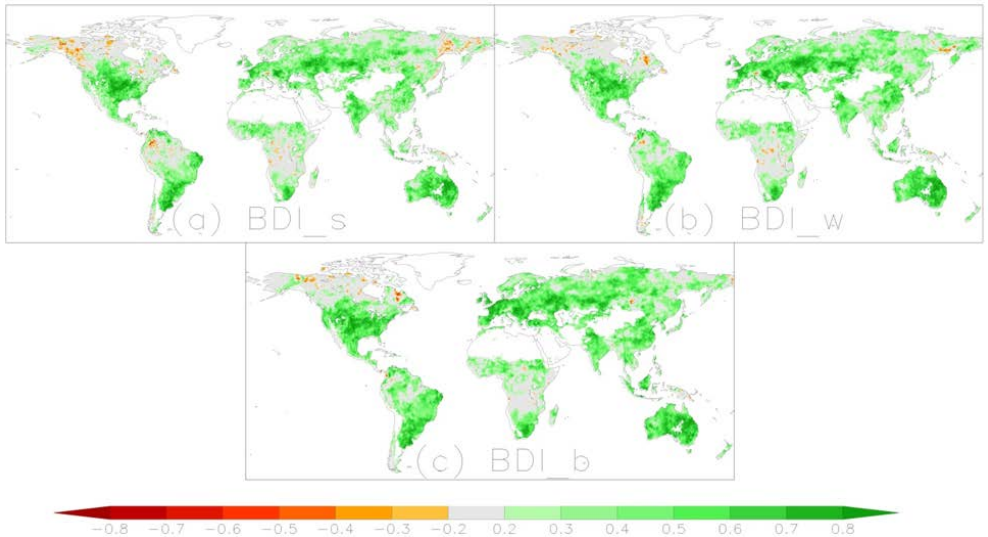
Australia: BDI_s (0.50), BDI_w (0.53), ***BDI_b (0.59)***;

South Africa: BDI_s (0.42), BDI_w (0.44), ***BDI_b (0.48)***;

Eurasia: BDI_s (0.36), BDI_w (0.38), ***BDI_b (0.40)***;

South America: BDI_s (0.35), BDI_w (0.43), ***BDI_b (0.48)***;

In the areas with weather stations and rain gauges sparsely distributed, the correlations between PDSI and BDIs are relatively low, such as northern Africa and the high latitude areas (Chen et al., 2002; Mu et al., 2013).



With respect to SPEI:

CONUS: BDI_s (0.46), *BDI_w (0.48)*, ***BDI_b (0.56)***;

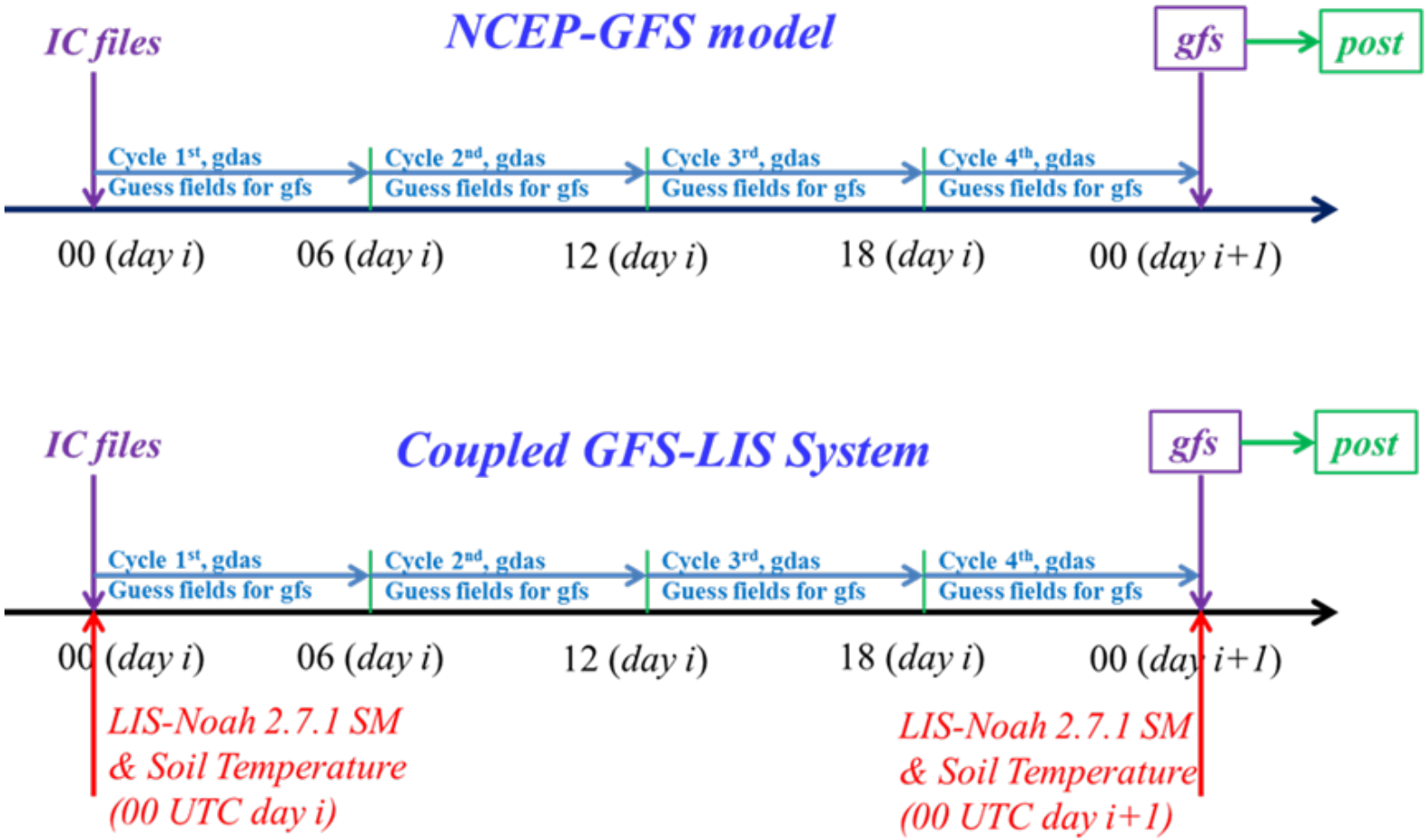
Australia: BDI_s (0.54), BDI_w (0.58), ***BDI_b (0.59)***;

South Africa: BDI_s (0.33), BDI_w (0.37), ***BDI_b (0.40)***;

Eurasia: BDI_s (0.33), BDI_w (0.37), ***BDI_b (0.40)***;

South America: BDI_s (0.27), BDI_w (0.32), ***BDI_b (0.37)***;

3. Improvements in Weather Forecasts

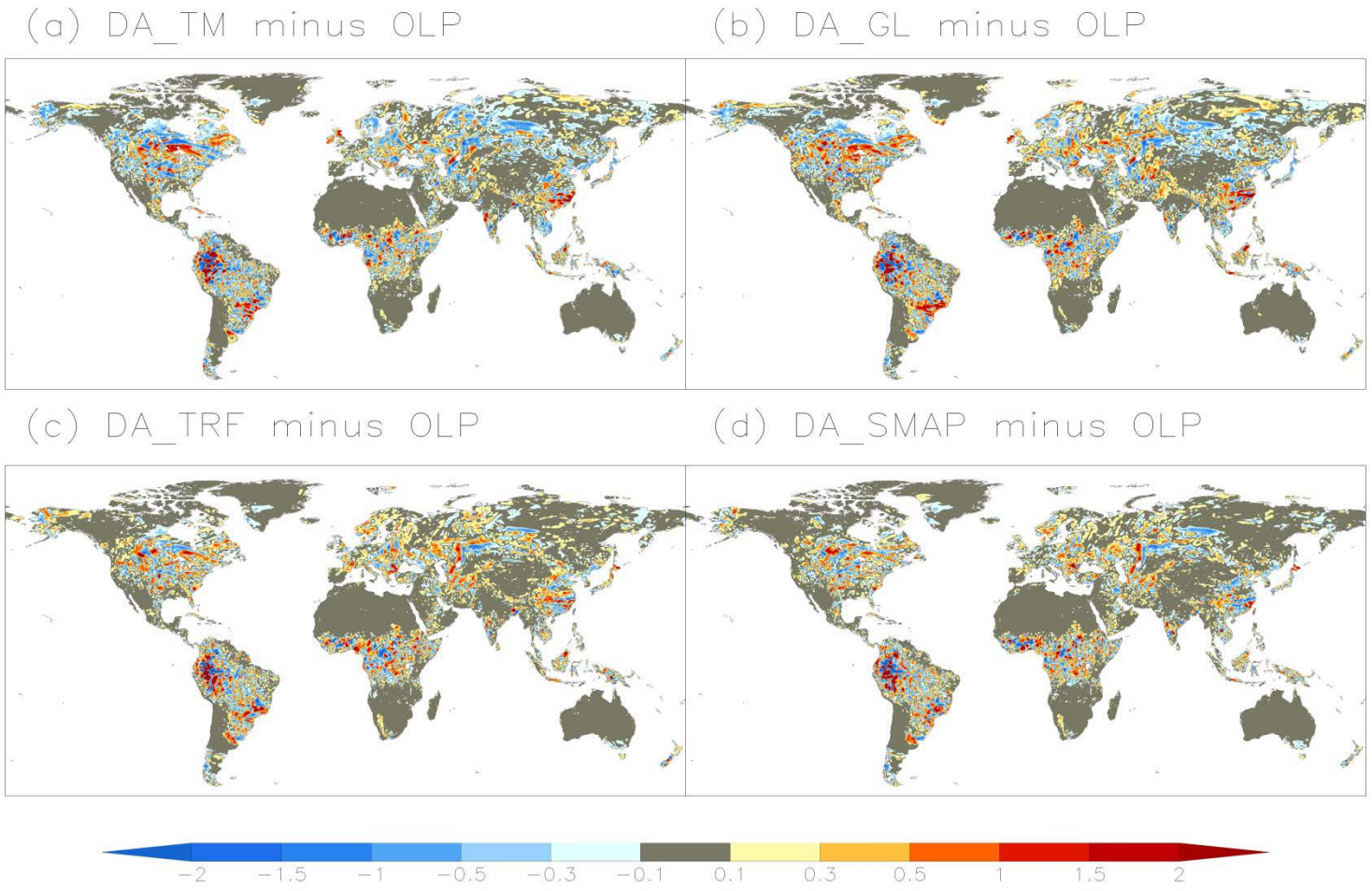


Steps of the GFS and the coupled GFS-LIS system. The acronym IC indicates initial conditions.

3. Improvements in Weather Forecasts

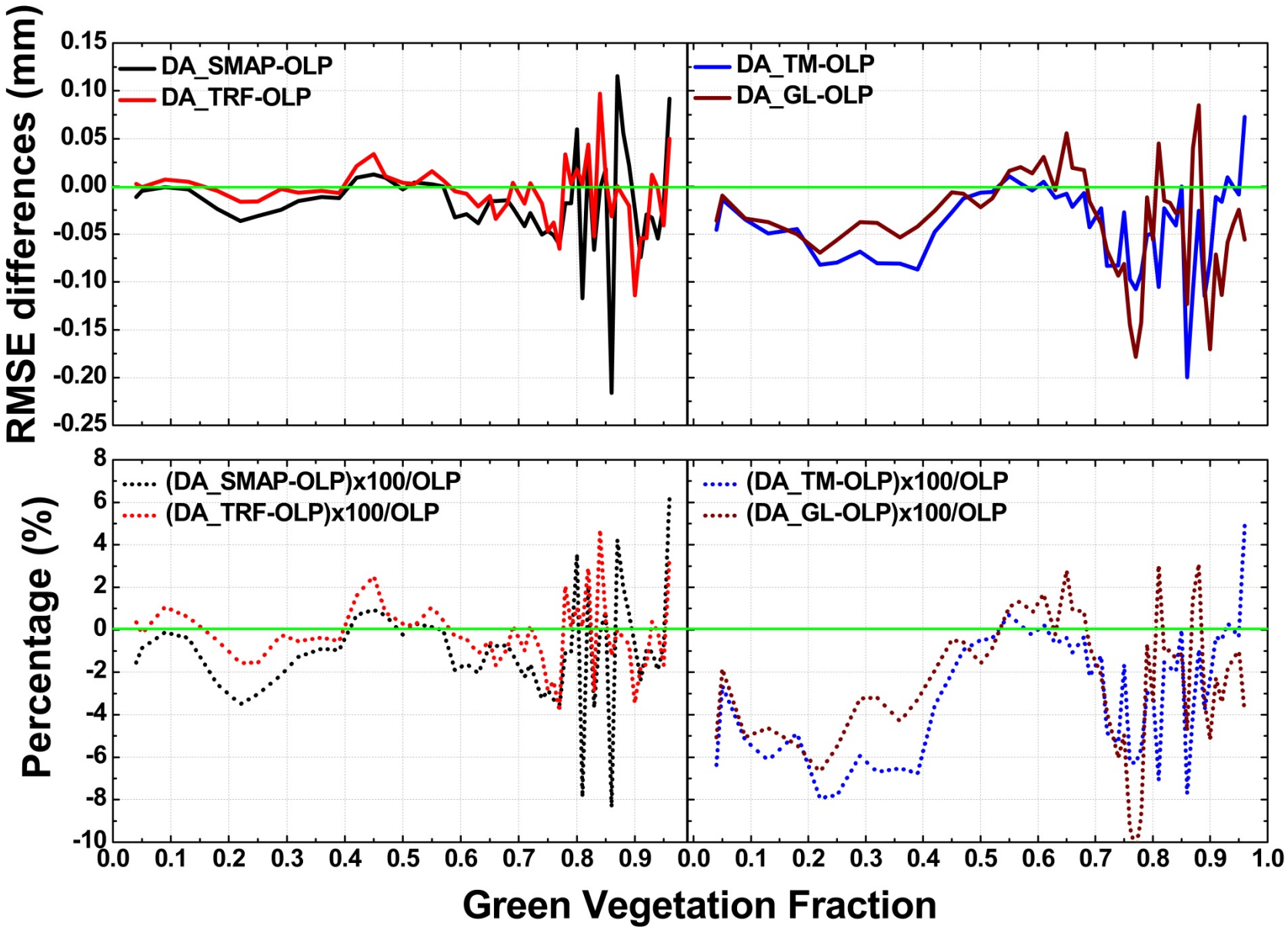
Bias-correction methods:

1) DA_TM: monthly cumulative distribution function (CDF);
2) DA_GL: global CDF method;
3) DA_TRF: the linear transformation technique;
4) DA_SMAP: SMAP retrievals were not scaled at all.



With respect to the GLDAS precipitation product, differences in RMSE for the predicted 3-hourly precipitation between each of the four DA cases and the OLP case over 2-11 May, 2015.

3. Improvements in Weather Forecasts



4. Summary

i. Model simulations and remotely sensed observations of SM *can be objectively translated into useful information for drought monitoring and early warning*, in turn can reduce drought risk and impacts.

ii. Over the BDI_s and BDI_w, the BDI_b presents an advantage of higher consistence with the climatological PDSI and SPEI datasets and current operational USDM product. In addition to operational insights, *the BDI_b is recommended as an indicator* which can merge new upcoming satellite SM products and more available agricultural drought evaluations when they can respect to the TCEM assumptions.

iii. Based on the developed GFS-LIS coupled system, positive impacts of assimilating soil moisture retrievals are found for *precipitation predictions*.

iv. Effectiveness of satellite soil moisture assimilation is *significantly impacted by bias-correction methods*, and assimilating soil moisture retrievals using *the monthly CDF matching bias-correction method* into the GFS model is suggested.

Thanks for your attention !